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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/765,833	01/29/2004	Kazuyuki Higashi	248232US2S	2348
22850	7590	06/16/2005	EXAMINER	
OBLON, SPIVAK, MCCLELLAND, MAIER & NEUSTADT, P.C. 1940 DUKE STREET ALEXANDRIA, VA 22314			SANDVIK, BENJAMIN P	
			ART UNIT	PAPER NUMBER
			2826	

DATE MAILED: 06/16/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

## Office Action Summary

Application No.

10/765,833

Applicant(s)

HIGASHI ET AL.

Examiner

Ben P. Sandvik

Art Unit

2826

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

### Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

### Status

- 1) ☐ Responsive to communication(s) filed on \_\_\_\_.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

### Disposition of Claims

- 4) ☒ Claim(s) 1-13 is/are pending in the application.
- 4a) Of the above claim(s) 3, 4, 6 and 11-13 is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 1, 2, 5 and 7-10 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_ are subject to restriction and/or election requirement.

### Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on \_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

### Priority under 35 U.S.C. § 119

- 12) ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☒ All b) ☐ Some \* c) ☐ None of:
- 1) ☒ Certified copies of the priority documents have been received.
  - 2) ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_.
  - 3) ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\* See the attached detailed Office action for a list of the certified copies not received.

### Attachment(s)

- |  |   |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892)                        | 4) <input type="checkbox"/> Interview Summary (PTO-413)                     |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948)               | Paper No(s)/Mail Date. ____   |
| 3) <input checked="" type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) |
| Paper No(s)/Mail Date ____   | 6) <input type="checkbox"/> Other: ____                                     |

## DETAILED ACTION

### *Claim Rejections - 35 USC § 103*

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

Claims 1, 2, 5, and 7-10 are rejected under 35 U.S.C. 103(a) as being unpatentable over Zhou et al (U.S. Patent #6251781), in view of Chu (U.S. Patent #20020025675).

With respect to **claims 1, 2 and 5**, Zhou teaches a semiconductor substrate (Fig. 9, 50); an active element structure formed on the semiconductor substrate (Col 3 Ln 43-44); first insulating film provided above the semiconductor substrate (Fig. 9, 54); a first interconnect layer provided in a surface of the first insulating film and composed of copper (Fig. 9, 58); a second insulating film provided on the first insulating film (Fig. 9, 22); a connection hole formed the second insulating film and having a bottom connected to the first interconnect layer (Col 3 Ln 55-56); a connection plug provided in the connection hole (Fig. 9, 80), an interconnect trench formed in surface of the second insulating film and having a bottom connected to the connection hole (Col 3 Ln 55-56); and a second interconnect layer provided in the interconnect trench (Fig. 9, 80), but Zhou does not teach that the connection plug is composed of a single crystal of copper filling the connection hole so that no other crystals of copper are provided

in the connection hole, or that the copper of the connection has the same crystal orientation as that in a part of the first interconnect layer which is located in the first interconnect layer. Furthermore, Zhou teaches a diffusion preventing metal film extending from a bottom of the connection hole to a side wall of the connection hole and an inner surface of the interconnect trench and composed of TaN (Col 4 Ln 12), but does not teach that the diffusion preventing film has a thickness of 0.1 to 1 nm.

Chu teaches that copper via plugs and filled trenches can be formed with a single crystal structure (Abstract), and a barrier layer with a thickness of 10 Angstroms, or 1 nm (Paragraph 78). It would have been obvious to one of ordinary skill in the art at the time the invention was made to form the via plugs of Zhou with a single crystal structure as taught by Chu in order to take advantage of the low resistivity of single crystal interconnects, and to provide the first interconnect layer and connection plug of Zhou with copper using the single crystal method of Chu, giving the two parts the same crystal orientation, in order to simplify the manufacturing process, and to make the thickness of the barrier layer in Zhou to be 1 nm thick as taught by Chu in order to meet the thickness requirements being sought currently for IC technology.

With respect to **claims 7-10**, Zhou teaches a semiconductor substrate (Fig. 9, 50); an active element structure formed on the semiconductor substrate (Col 3 Ln 43-44); first insulating film provided above the semiconductor substrate (Fig. 9, 54); a first interconnect layer provided in a surface of the first insulating

film and composed of copper (Fig. 9, 58); a second insulating film provided on the first insulating film (Fig. 9, 22); a connection hole formed the second insulating film and having a bottom connected to the first interconnect layer (Col 3 Ln 55-56); a connection plug provided in the connection hole (Fig. 9, 80), an interconnect trench formed in surface of the second insulating film and having a bottom connected to the connection hole (Col 3 Ln 55-56); and a second interconnect layer provided in the interconnect trench (Fig. 9, 80), but Zhou does not teach that the filling of the connection hole with copper is done by epitaxial growth so that no other crystals of copper are provided in the connection hole. Furthermore, Zhou teaches a diffusion preventing metal film covering inner surface of the connection hole and interconnect trench and composed of TaN (Col 4 Ln 12), but does not teach that the thickness of the diffusion preventing metal layer is 0.1 to 1 nm). Still further, Zhou does not teach that filling the connection hole includes forming a base film composed of copper, on the interconnect layer at the bottom of the connection hole, and forming the copper by an electroplating method using the base film as a base.

Chu teaches that copper via plugs and filled trenches can be formed with a single crystal structure (Abstract), by molecular beam epitaxy (Paragraph 43), and a diffusion barrier with a thickness of 1 nm (Paragraph 78). Furthermore, Chu teaches filling the connection hole includes forming a base film composed of copper, on the interconnect layer at the bottom of the connection hole, and forming the copper by an electroplating method using the base film as a base

(Paragraphs 74 and 75). It would have been obvious to one of ordinary skill in the art at the time the invention was made to form the via plugs of Zhou with a single crystal structure by molecular beam epitaxy or electroplating as taught by Chu in order to take advantage of the low resistivity of single crystal interconnects, and to make the thickness of the barrier layer in Zhou to be 1 nm thick as taught by Chu in order to meet the thickness requirements being sought currently for IC technology.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Ben P. Sandvik whose telephone number is (571) 272-8446. The examiner can normally be reached on Mon-Fri.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nathan Flynn can be reached on (571) 272-1915. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic

Business Center (EBC) at 866-217-9198 (toll free).  
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